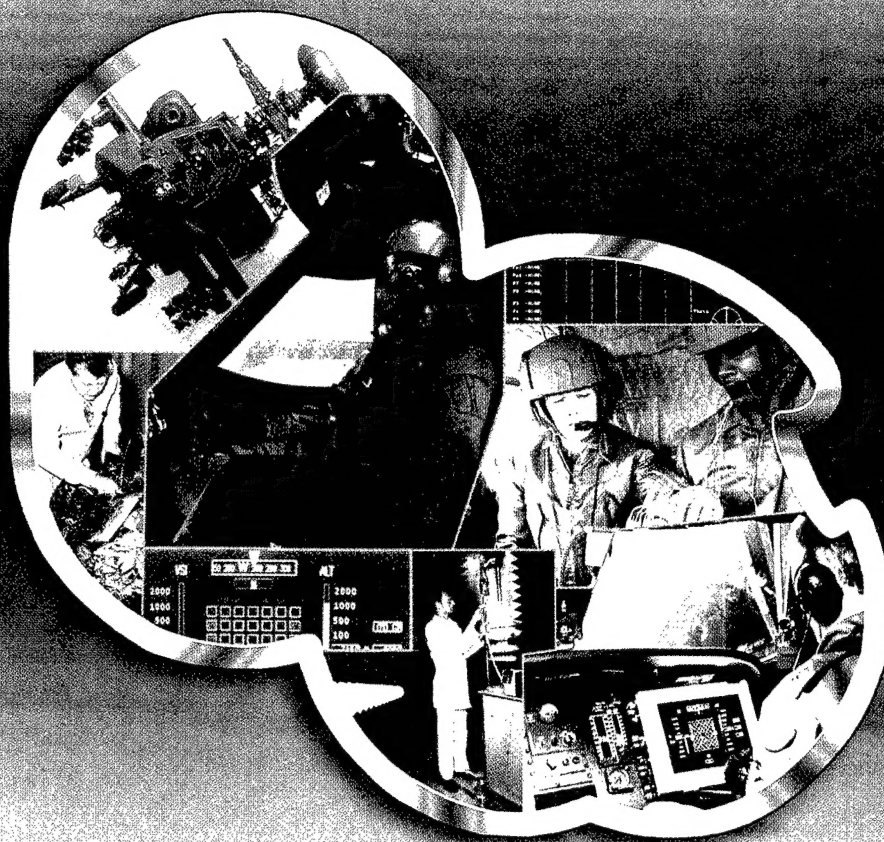


USAARL Report No. 2001-07

# Laser Issues for Army Aviation: Questions & Answers

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Aircrew Health and Performance Division

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## Introduction

Lasers have been on the modern battlefield for decades. They are used primarily as rangefinders and target designators; however, in the past the high cost and technological sophistication of lasers have limited their fielding to national armies. Their large size and power requirements have further limited their presence on the battlefield.

Within the last few years, however, technological advances have reduced significantly both the size and power requirements of lasers. Instead of lasers operated at only a few fixed wavelengths, they now can emit energy virtually anywhere within the electromagnetic spectrum and the cost has plummeted. Low power laser pointers operating in the visual region of the spectrum can be purchased through mail order companies and in local discount stores.

Within the military community, especially in aviation, lasers are a major potential threat to the aviator's most important source for gathering information, his or her eyes. Vision is of paramount importance to the aviator in flight. Either through hostile intentions or through training accidents, the aviator's vision has been susceptible to damage through exposure to lasers. Today, this potential threat has increased significantly with the easy availability of low-cost laser pointers.

The U.S. Army recognizes the need to address the issues of lasers, laser protection and laser injuries. The former Letterman Army Institute of Research, the Presidio, San Francisco, CA, initiated a series of conferences, "Lasers on the Modern Battlefield." The first conference was held in 1979. These conferences brought together researchers, medical personnel, and the Army user community to address laser issues. The XXII Lasers on the Modern Battlefield Conference was held at Brooks Air Force Base, San Antonio, TX, in February 2001, hosted by the U.S. Army Medical Research Detachment.

While a considerable amount of knowledge has been acquired over the years on issues regarding lasers, this knowledge does not always reach the field. Aviators often do not have sufficient awareness of changes in the laser threat, of what is available to protect against it, and of the most recent medical advice on dealing with laser exposure. The U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, and the office of the Product Manager, Aircrew Integrated Systems (ACIS), Redstone Arsenal, AL, often fields questions in these areas. As a result of these questions and the apparent need for a more informed aviation community, a three-part series of questions and answers on laser topics has been written for publication in the U.S. Army Safety Center's aviation safety newsletter, *FlightFax*. The questions used in the series were divided into three areas: Lasers on the modern battlefield, laser protection and laser injuries. The questions answered reflect those typically and repeatedly asked of the two organizations above. This report collects these questions as presented in the three-part *FlightFax* series of articles into a single resource.



## Part I: Lasers and aviation on the modern battlefield

The U.S. Army fields a number of laser systems. They are used primarily as rangefinders or target designators. The first systems were fielded in the early 1970s. Yet, even today, lasers are a source of much misunderstanding. This section, the first of three parts which look at lasers, laser protection and laser injuries as they apply to the aviator in the cockpit, attempts to address this confusion.

Q: How does laser light differ from "normal" light?

A: While "light" is "light," light produced by a laser has three unusual properties. The first is that laser light (energy) is emitted almost at a single wavelength (actually a very narrow band of wavelengths). A second property is that laser energy can travel greater distances with very little spreading out (divergence). Laser beams have been bounced off the moon. The third property is called coherence, which means the light waves from a laser are in step (or in phase) with one another.

Q: How are lasers named or classified?

A: A given laser can be classified in several ways. One way is by the region of the electromagnetic spectrum in which the laser energy is emitted; e.g., visible, infrared (IR), or x-ray. This is defined by the laser's wavelength (measured in nanometers [nm]). Another way is by whether the laser produces a continuous beam or a series of pulses. Or, lasers can be named according to the optical medium used within the laser to produce the light; e.g., gas, solid-state, dye, etc.

Q: How far away from a laser do I have to be to be totally safe?

A: The distance from a laser beyond which the maximum permissible exposure (MPE) is not exceeded is known as the "Nominal Ocular Hazard Distance (NOHD)". For military lasers, this distance can be up to 10 kilometers for the unaided eye and up to 100 kilometers if viewed through unprotected optics.

Q: How do lasers vary in power?

A: Laser power is measured in units called "watts." Lasers, such as those used in science classrooms, are measured in thousandths of a watt or "milliwatts." Industrial lasers can range in the thousands of watts or "kilowatts." Pulsed lasers can deliver power in the "megawatts per pulse" range. Lasers can be classified by their power output (Class 1,2,3, or 4). The lowest power lasers, Class 1, are those that, under normal conditions, cannot cause damage even when viewed directly. Class 4 lasers are high power lasers capable of causing fires, damage to the skin, and damage to the eye, potentially even from reflections.

Q: What is a visible laser?

A: Any laser operating at a wavelength between 380-730 nm can be seen by the human eye. You can expect to encounter a variety of "colors" from common laser pointers ranging from blue (480 nm) to green (532 nm) to red (670 nm).

Q: Are there lasers I can't see?

A: Yes, military laser rangefinders/designators operate at longer wavelengths and are not visible. Such lasers emit at wavelengths greater than 780 nm and are referred to as infrared

lasers. Even though you can't see infrared lasers, the eye can still focus this energy on the retina creating the potential for injury.

Q: Can a laser change its wavelength?

A: Currently, all lasers you might encounter are single or "fixed wavelength" lasers. However, "tunable or agile" lasers exist in the laboratory. These lasers have the ability to change the wavelength at which they produce energy. These lasers use an organic dye material as the laser medium and can emit energy over a continuous band of wavelengths.

Q: What type of laser is used on the AH-64 and OH-58D?

A: The rangefinder/designator on the AH-64 and OH-58D is a Neodymium:YAG pulsed laser. It is a solid-state laser using an yttrium-aluminum-garnet (YAG) crystal as the lasing medium. It produces nonvisible laser energy pulses in the infrared at approximately 1064 nm. Pulsed lasers put out energy in a single pulse or in a train of pulses. The important characteristics of pulsed lasers are their pulse frequency rates (PFR) and their energy or power per pulse. The most common pulsed laser is called a Q-switched laser. Its pulses are typically 20 billionths of a second long but can deliver a million watts or more of power per pulse.

Q: Are lasers a threat to me?

A: Yes, although lasers have been around for a long time, today they are cheaper, smaller, more easily obtained, and produce more energy than in the past. The number of reported laser incidents to date is small, but the potential for such incidents is growing significantly. Of greatest concern to the aviator is the impact of laser exposure to the eye, the results of which could include dazzle, flash blindness, and retinal damage.

Q: Does my aircraft windshield stop laser energy?

A: In general, no. The typical aircraft windshield is highly transmissive to both visible and near-infrared lasers. It will stop ultraviolet and far-infrared lasers, but these are the least likely to be encountered.

Q: Is there such a thing as an "eye safe" laser?

A: The claim of being "eye safe" means that you supposedly are able to view the laser directly without incurring damage to the eye. This phrase is often misused. A wise philosophy is never to intentionally look directly into any laser device.

Q: Should I worry about the laser pointers being sold in department stores?

A: Yes and no. Laser pointers are inexpensive (\$5 to \$500) and readily available. They produce laser energy in a variety of colors (wavelengths), mostly green and red. These devices are very low power and unlikely to be a source of damage to the aviator. However, they are capable of producing dazzle (a temporary loss of vision that will return immediately when the light source is removed) or flash-blindness (again, a temporary loss of vision, but this loss can persist for several minutes even after the laser source is no longer present). These effects are similar to being "blinded" by a bright light or flashbulb. It is obvious that even the temporary loss of vision in the aviation environment could have catastrophic results. The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) has developed an excellent web-based presentation on laser pointers available from their site at <http://chppm->

[www.apgea.army.mil/laser/laser.html](http://www.apgea.army.mil/laser/laser.html). Safety officers can request it in various computer media formats.

Q: Where can I get more information on lasers?

A: Questions about lasers can be answered by contacting USACHPPM, Laser/Optical Radiation Program, DSN 584-3932 or COM (410) 671-3932.

## Part II: Laser protection

In Part I, we answered questions concerning the nature of lasers on the modern battlefield. In this section, Part II, we address questions about laser protection. The challenge of providing protection against an ever-changing laser threat, while not compromising performance, is a difficult one.

Q: What is my greatest concern from exposure to lasers?

A: For the aviator, the greatest concern is potential injury to the eye. While the skin does absorb laser energy, much more energy is required for skin damage than for eye damage.

Q: Why is the eye at such great risk?

A: The eye is designed specifically to focus light onto the retina of the eye. For continuous wave lasers, the eye will focus a higher concentration of energy on a very small area. In addition, laser energy can be absorbed by the various parts of the eye, causing thermal damage. Pulsed lasers can cause damage by a shock-wave effect, similar to that caused by a bullet.

Q: What parts of the eye can be affected?

A: Ultraviolet and far-infrared laser energy can damage the cornea. Visible and near-infrared lasers will be focused on and damage the retina.

Q: What are my chances of being seriously injured by lasers?

A: To date, only a handful of laser injuries have been documented, and most of these have been self-inflicted. Whether damage will occur, and to what extent, depends on many factors. These include the laser's wavelength and power, exposure duration, distance from laser source, pulse repetition frequency (for pulsed lasers), and the nature of the exposure (direct beam or reflection).

Q: Do my sunglasses or standard flight visors provide any protection against lasers?

A: Your sunglasses and standard clear/tinted visors provide virtually no "real" protection against military lasers, no more than a sheet of paper would provide protection from bullets. However, they will afford you some protection against dazzle and flash blindness.

Q: What form of laser protection is available to the aviator?

A: Both 2-notch (NSN 8415-01-394-8026) and 3-notch (NSN 8415-01-394-8024) laser visors have been fielded for the HGU-56P flight helmet. The 2-notch is "light green" in color; the 3-notch is "bronze or brownish." The notches cover the military laser wavelengths considered to present the greatest threat. The 2-notch protection can be worn either day or night, but the 3-

notch protection is too dark to be worn safely at night. For the Apache aviator, a 2-notch visor (NSN 1270-01-327-3107) is available. Spectacles (made with pale green KG-3 or KG-5 glass) protecting against the AH-64's own laser are available.

Q: What is meant by a "2-notch or 3-notch" laser visor?

A: A "notch" refers to a section of the spectrum for which your visor offers protection. Therefore, a "2-notch" visor provides protection against two different lasers, a "3-notch" against three different lasers. However, you need to know which laser wavelengths your visor protects against. The 2-notch visor protects against Ruby (visible red) and Neodymium YAG (infrared) lasers. The 3-notch protects against these two and one additional wavelength that is classified as FOUO.

Q: How is the protection level of a visor rated?

A: Any laser protective device is rated by: a) the wavelengths it protects against and b) the amount of protection for each of those wavelengths. The amount of protection is called the "optical density" or "OD." An OD value of 1 means 1/10th of the incoming laser energy gets through; OD=2 means 1/100th gets through; OD=3 means 1/1000th, etc. OD values of greater than 3 are usually required to provide adequate protection.

Q: How does laser protection work?

A: Current laser protection methods are generally of two types: absorption and reflection. Absorption is achieved by mixing a dye with the standard visor during molding. The dye absorbs the laser energy that strikes the visor. Reflective coatings are typically "sandwiched" between two layers of polycarbonate and reflect the laser energy.

Q: Does the protection level of my laser visor hold up over time?

A: No, most dyes used in absorption visors are affected by sunlight exposure. Current guidance is that absorptive visors should be replaced after 600 hours of sun exposure. To maximize the life of laser visors, wear them only when a laser hazard/threat is anticipated. Reflective coatings are not known to degrade over time or with exposure to sunlight.

Q: Is there a performance price for wearing laser protection?

A: Yes, any time you have to look through one more layer between you and the outside world, your visual performance will be degraded, even if ever so slightly. In addition, since the protective device may be designed to block certain visible wavelengths, it may affect your ability to view cockpit displays and warning lights.

Q: Do scratches on my laser visors affect my laser protection?

A: Minor scratches will diffract and defocus the intensity of the laser, which actually increases the laser protection. Large scratches that might allow a laser to penetrate will be objectionable from a pilot's visual perspective and are easily identified.

Q: Can my mechanic/technician use my laser visor for protection while he is performing maintenance on the rangefinder/designator?

A: No. Your visor was designed to provide you adequate protection at operational combat ranges. A technician working on the system is working at point blank range. His OD requirements are much greater than yours.

Q: Does looking through optics give me protection against lasers?

A: No, direct-view optical systems do not provide protection .... unless they specifically have a laser filter installed, and, even then, they protect only against those laser wavelengths for which the filter was designed.

Q: Do my NVGs offer laser protection?

A: Yes. When you are looking in the direction of the laser, the energy does not pass through the goggles. But, the goggles will bloom. And, of course, if you are looking under or around the goggles, you are at risk.

Q: What can and should I do if I am exposed to a laser?

A: Next month, in the third and final part of this laser series, questions regarding laser injuries will be answered.

Q: Who can I contact for more information on laser visors?

A: HGU-56/P wearers can contact Mr. Jim Hauser, product engineer, PM-AES, DSN 897-4267, (256) 313-4267, [jim.hauser@peoavn.redstone.army.mil](mailto:jim.hauser@peoavn.redstone.army.mil). Apache aviators can contact Mr. Larry Best, Aircraft Armament Group Leader, DSN 793-2329.

### Part III: Laser-related injuries

In the first two sections of our laser series, we answered questions on the nature of lasers and how you can protect yourself from exposure. The final question remains: What do you do if you're in the wrong place at the wrong time .... if you think you've been lased?

Q: What is the most important thing to remember if I am lased?

A: *Remain calm.* Being lased is comparable to being hit by a sniper .... it's sudden, unexpected and potentially highly dangerous. But, the odds are very much in your favor, since most incidents produce temporary symptoms and no permanent loss of sight. While serious injuries can occur, they are atypical in flight scenarios.

Q: If I am lased, what is the least effect I might experience?

A: A temporary dazzle effect, similar to what you might expect from any sudden bright light in your face, or flash blindness, which can last up to minutes, are the least injurious effects you may encounter. While some loss of visual acuity may occur initially, neither condition will result in permanent loss of sight. However, at low altitudes, this can have catastrophic results.

Q: What is the range of symptoms associated with laser injuries?

A: Laser-related injuries depend upon the type of laser involved, its power and range from source. Injuries can range from temporary (minutes) loss of vision to serious retinal burns and

hemorrhage (bleeding). Pain may or may not occur. Some of these injuries result in no discomfort, other than a mild watering of the eyes. Injuries involving the cornea, even relatively mild ones, can result in excruciating pain. With or without symptoms, any laser exposure can be serious and should not be discounted.

Q: What type of symptoms will I experience if I receive a retinal burn or hemorrhage?

A: You may or may not experience pain depending upon the location of the injury. In the event of a retinal hemorrhage, your vision will begin to blur and become clouded as blood leaks into the middle of the eye. As hemorrhaging continues, vision may be totally obscured in the affected eye. While retinal hemorrhages are sometimes treated surgically, and the eye may remain clouded for several months, the eye is remarkably good at repairing itself.

For retinal burns, some vision loss may occur, again depending upon the location of the injury. In severe cases, such as those involving pulsed lasers, the intense heat produced will superheat the tissue causing mechanical disruption, spreading the damage to surrounding areas. The mechanical force involved can blow a hole through the retina, resulting in additional hemorrhaging and possible severe vision loss.

Q: Should physical damage be my only concern?

A: As with any injury, shock and psychological trauma also can occur. This is especially true with any type of retinal hemorrhage. The trauma surrounding the event, and the fear of loss of vision, can be overwhelming. Over the long term, the psychological stress experienced will depend upon the aviator's initial response to the injury, his knowledge and training about laser weapons, and the treatment received. The emotional stress received from a laser injury should not be overlooked.

Q: If I suffer a laser injury, are there steps I can take to reduce its severity?

A: Although there is little you can do for laser exposures, there is a lot you should not do. **DO NOT RUB YOUR EYES.** Cases have been reported where victims rubbing their eyes have actually caused abrasions and worsened their injuries. Keep hands and fingers away from the eyes to avoid possible contamination and sources of infection. Current medical advice is not to patch the eye.

Q: Once I have landed, what should I do?

A: *Immediately report to the flight surgeon.* While laser injuries can be minor, serious injuries are not always readily apparent. Medical complications can often be avoided by immediate treatment. It is important for the victim to remember that laser-related injuries are seldom life threatening and the chances for at least partial recovery are usually quite good.

Q: What medical treatment might I expect?

A: Initially, expect a thorough eye examination by a trained ophthalmologist. This is standard procedure and allows for extensive examination of both the interior and exterior of the eye. Burns to the cornea are often treated with antibiotic ointments, mild pain relievers, and intramuscular analgesics. Small nonfoveal burns with little or no hemorrhaging are monitored, but no actual medical treatment is necessary. More serious burns and hemorrhaging may require surgical intervention.



Q: Where can I go for further information?

A: FM 8-50 *Prevention and Medical Management of Laser Injuries* (1990) is an excellent source of information, though somewhat dated. Additional information can be secured from the U.S. Army Center for Health Promotion and Preventive Medicine (<http://chppm-www.apgea.army.mil>).

### Summary

Laser rangefinders/target designators are a vital part of effective tactical weaponry, and, therefore, accidental exposure is a serious potential. The availability of inexpensive laser pointers increases the potential of laser exposure. While the external threat of laser exposure is increasing, it is worth noting that most laser eye injuries to date have been self-inflicted.

Laser protection is accessible and effective. Unfortunately, because of the variety of lasers available, protective devices must be coordinated with the greatest laser exposure risks. No one laser protective device can protect from all wavelengths and energies.

There are no simple answers for laser protection. For the aviator, the potential for laser exposure is just another situation that requires vigilance, training, knowledge and a cool head.



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